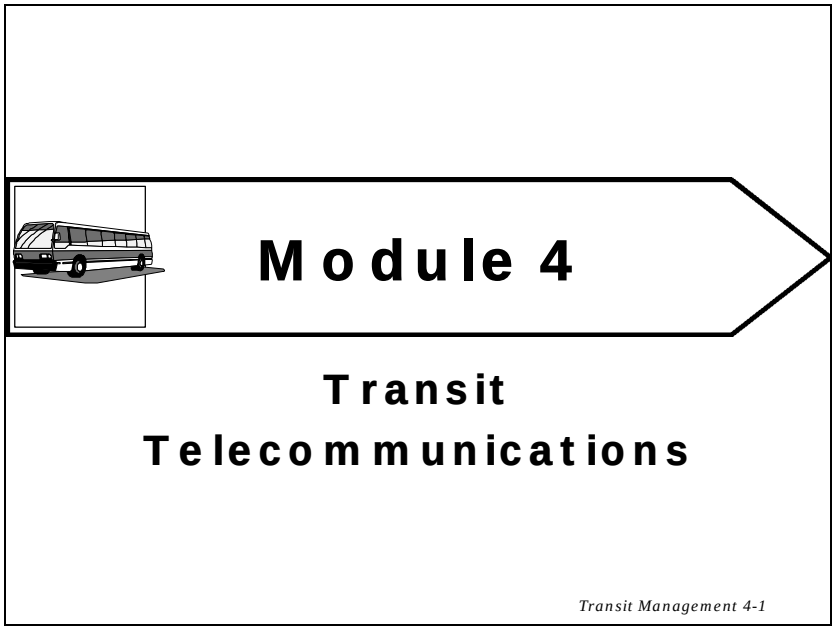
Module 4: Transit Telecommunications



TRANSIT MANAGEMENT TRAINING ROADMAP	
	Module 1: Introduction to ITS and APTS
	Module 2: Automatic Vehicle Location Systems
	Module 3: Automated Transit Information
	Module 4: Transit Telecommunications
	Module 5: Transit Operations Software
	Module 6: Paratransit Computer-Aided Dispatch
	Module 7: Electronic Fare Payment
	Module 8: Technologies for Small Urban and Rural Transit Systems
	Module 9: Stages of ITS Project Deployment
	Module 10: What Can ITS Do for Me?

Telecommunications:
- Terms
- Spectrum management
- Issues

Technology alternatives:
- Trunked Systems
- Other

Module 4: Transit Telecommunications
1.5 Hours

Introduction

Schedule

The following table shows the times and activities for this module.

Time	Activity
5 min.	*Lecture/Discussion:* Introduction
25 min.	*Lecture/Discussion:* Telecommunications Issues
30 min.	*Lecture/Discussion:* State-of-the-Art Alternatives
OPTIONAL	*Lecture/Discussion:* Technology Alternatives
30 min.	Exercise 4-1: Custom Course Notes
90 min.	Total Time

To prepare

Have the following article available in the classroom:

- *Impact of Radio Refarming on Transit Communications* by TCRP

Note to instructor: Telecom technology is changing rapidly. Update your information before teaching the class.

Continued on next page

Introduction, Continued

Length

5 minutes lecture/discussion

Slide: Goal

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Goal

Read the goal of this module.

Say: This module will provide an overview of the role of telecommunications in:

- transit operations
- integration of transit into traffic management and other services within a metropolitan ITS system

It will also review:

- telecommunications technology
- telecommunications issues that are facing transit
  - ◊ the “red flags” you may need to consider in the future

Objective

Read the module objective:

- Given an APTS Technology Reference table, students will list three benefits of using transit telecommunications in their agency.

Continued on next page

Introduction, Continued

Note: "Red Flag" Issues

The following telecommunications issues will be highlighted in this module:

- ITS/APTS will require increased communications; in general new **frequency allocations** will be very difficult or impossible to get.

- The FCC has mandated that mobile communications channels be **refarmed**, or reduced in bandwidth, in steps:
  - ◊ from 25 kHz to 12.5 kHz first
  - ◊ from 12.5 to 6.25 kHz in the future

- Transit systems that plan to replace their communications systems must ensure that new equipment accommodates the new channel bandwidth requirement.

- The FCC is making available spectrum which has been **reallocated** from Federal government use to private sector use; a significant portion of this spectrum is being made available for public safety applications. Transit may be able to share in these new allocations.

- As part of the **public safety** initiative the FCC is encouraging the establishment of wide area, multi-user trunked 800 MHz systems; some states, for instance, are in the process of setting up such systems. The establishment of shared communications systems over a local area is also being encouraged.

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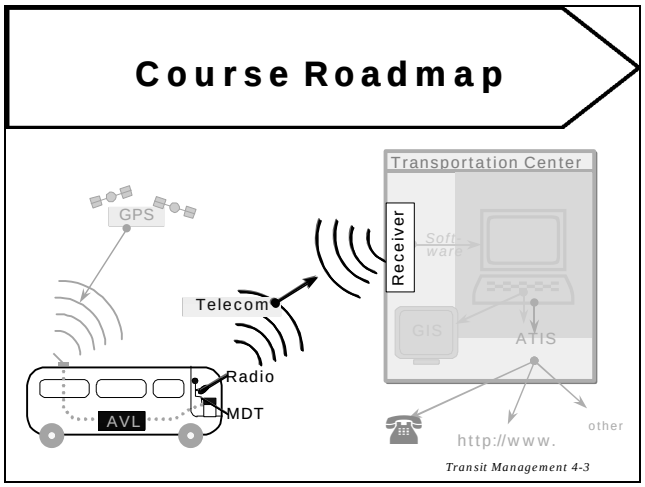
Introduction, Continued

Slide: Course Roadmap



Orient with the roadmap

Show slide.

Show the class where they are with the roadmap on page 1 of their SG.

Explain that we've seen one of the three parts of the ITS Infrastructure (traveler information) that we discussed in Module 1.

- AVL began the discussion of the second: transit fleet management
- Telecommunications continues the discussion of fleet management.

Continued on next page

Introduction, Continued

Slide: Module Outline

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Module outline

Explain the outline of the module.

Say: Integrated ITS systems will be heavily dependent on telecommunications.

- In addition, as new technology is phased into public transportation, the present communications capabilities will not be sufficient to accommodate the new technology and keep the old systems running.

Telecommunications Issues

Length 25 minutes lecture/discussion.

Slide: Issues in Telecommu-nications **Error! Not a valid link.**

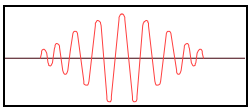
Outline **Explain** outline of lecture/discussion.

Definitions **Say**: As we get into our definitions, please turn to page 6 in your SG, Table 4-1: Telecommunications Terms and Definitions.

- These are provided for your reference so we are all using the terms the same way in this course.
- We will be reviewing some of these same terms in the next few minutes.
- You may want to leave this page out for reference, or tag it with a sticky note.
- This table is from the glossary of the ITS Telecommunications Awareness Course.
  - ◊ This module focuses on basics and on where to go for more information, e.g. the Awareness course. We'll be telling you more at the end of the module.

Continued on next page

Telecommunications Issues, Continued

Terms and Definitions	
Amplitude	The *level* of the signal; it can be measured in more than one way (volts peak or volts peak-to-peak)
Analog	Implies continuous variable physical quantities such as varying voltages, frequencies, etc. For example: voice signal 
Attenuation	Reduction or decrease in signal amplitude or signal strength during transmission from one point to another. Usually expressed or measured in decibels (dB). The opposite of Gain.
Bandwidth	The range of frequencies that can be transmitted by a communications channel, a transmission facility, or a transmission medium, expressed in hertz (Hz).
Channel	A single transmission path provided from a transmission medium between two points either by physical separation (e.g., multipair cable) or by electrical separation (e.g., frequency or time-division multiplexing). May refer to a one-way path or, when paths in the two directions of transmission are always associated, to a two-way path. It is usually the smallest subdivision of a transmission system by means of which a single type of communications service (that is, a voice, teletypewriter, or data channel) is provided.
CODEC (ENCODER/ DECODER)	An electronic device that converts audio or video (which are analog signals) into digital signals and vice versa. Encoder is an analog to digital converter and Decoder is a digital to analog converter.
Digital	A signal that has a limited number of discrete states before transmission, in the form of 0s and 1s; e.g., a light switch (either on or off)
FCC	Federal Communications Commission (FCC) A board of commissioners, appointed by the President of the United States under the Communications Act of 1934, having the power to regulate interstate and foreign communications originating in the United States by wire and radio.
Frequency	The number of repetitions (cycles) or events per unit of time of a complete waveform. When the unit of time is 1 sec, the measurement unit is usually expressed in Hertz (Hz).

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Telecommunications Issues, Continued

Terms and Definitions	
Full Duplex	The two-way simultaneous operation of a voice or data-communications link between devices in which either user transmits at will at the same time.
Half Duplex	A type of two-way communication transmission that affords communication in either direction but only in one direction at a time.
Interference	Disturbance in signal transmission.
Medium	A substance or material regarded as suitable for the propagation of signals from one point to another, such as optical fiber, coaxial cable, copper wire, dielectric slab, water, air, or free space; usually in support of modulated radio, light, or acoustic waves.
Modulation	The process by which the amplitude, frequency, or phase of a carrier signal is varied in accordance with one of the characteristics of an information signal.
MOdulator/ DEModulator (MODEM).	A contraction of "modulator/demodulator." An acronym for equipment unit that performs both of these functions. The device converts digital data signals to analog signals for transmission over the voice telephone network. The term may be used when the modulator and the demodulator are associated in the same signal-conversion equipment. See also Data Set.
Multiplexing	The equipment or process for combining a number of individual channels into a common frequency band or into a common bit stream for transmission. The converse equipment or process for separating into individual channels is called demultiplex(ing).
Packet	A block of data sent over the network that transmits the identities of the sending and receiving stations, error control information, and a message.
Protocol	Hardware and software standards that govern transmissions. Examples of computer network communications protocols are Ethernet, Token Ring, etc.
Simplex	One-way transmission with no capability for changing direction.
Telecomm-unications	Derived from the Greek *tele, "far off"* and the Latin *communicare, "to share."* It is any process that enables users to pass to other users information of any nature delivered in any usable form: wire, radio, visible or any other means.

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Telecommunications Issues, Continued

Slide: Telecomm-unications: Definition

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Definition: Telecomm-unications

Define: Telecommunications: Derived from the Greek *tele, "far off"* and the Latin *communicare, "to share."* It is any process that enables users to pass to other users information of any nature delivered in any usable form: wire, radio, visible or any other means.

Throughout the course, the terms communications and telecommunications may be used interchangeably. The term communications can be used in a broader context, e.g., to describe conversations, while the term telecommunications is generally used to convey the sending of information between physical devices (transmitters and receivers).

Repeat the definition. Say: So our working definition of telecommunications is:

- any process that enables users to pass information to other users in a useable form via wire, radio, visible mode (e.g., laser networking), or any other means

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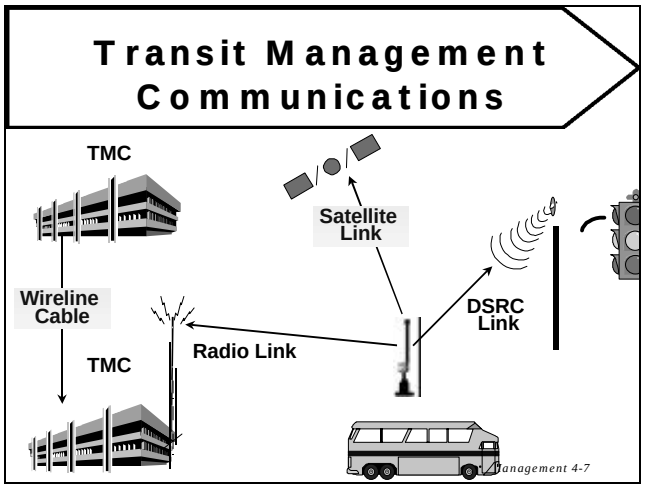
Telecommunications Issues, Continued

Slide: Transit Management Communications



Transit Management Communications

Say: The following technologies are commonly used for transit management communications:

- Radio communications for voice and data between vehicles and a TMC
- Satellite transmissions for Automatic Vehicle Location (AVL)
- Short range communications for signal priority and vehicle-to-roadside
  - ◊ DSRC (dedicated short range communications link)
- Wireline (e.g., optical fiber cable) to link transit and highway TMCs

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Telecommunications Issues, Continued

Transit comm-unications

Explain transit communications:

- fall into two categories:
  - ◊ wireline requires a physical connection to transmit signals (e.g., hard wiring between two Transit Management Centers, phone lines, computer networks)
  - ◊ wireless uses radio transmission which requires spectrum (as in the other communications shown in the slide)

Say: This course will focus on wireless since the most pressing telecomm issues facing transit are wireless ones. Refer to the ITS Telecommunications Awareness Seminar and the Telecomm Workshop for more info on wireline.

Explain that transit relies on wireless telecommunications to relay information between Transit Management Centers and vehicles.

- interoperability opportunities for both hardware and software exist, as well as intermodal opportunities

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Telecommunications Issues, Continued

Where is telecommunications used?

Say: APTS technology will require additional telecommunications for integrated functions (interoperability) such as:

- bus and control center
  - ◊ voice, data, and emergency
  - ◊ We'll talk more about this in a minute.
- fare payment
- park and ride
  - ◊ Park and ride lots can be tied to transit and traffic information systems, for example, "this garage is full" or "next bus arriving" message signs, as well as for integrated fare payment systems.
- HOV/express lane bus access
- adaptive signal systems
- intermodal telecommunications
  - ◊ workplace/home
  - ◊ wayside transfer center information
- on-board information

Bus to control center

- **Explain** that:
- The bus to control center link is the most critical APTS function requiring telecommunications.
- It usually requires telecommunications coverage throughout a large metropolitan area.
- It must be licensed by the Federal Communications Commission (FCC).

Dedicated link

Explain that some systems may need a dedicated link:

- safety and warning messages
- route guidance systems

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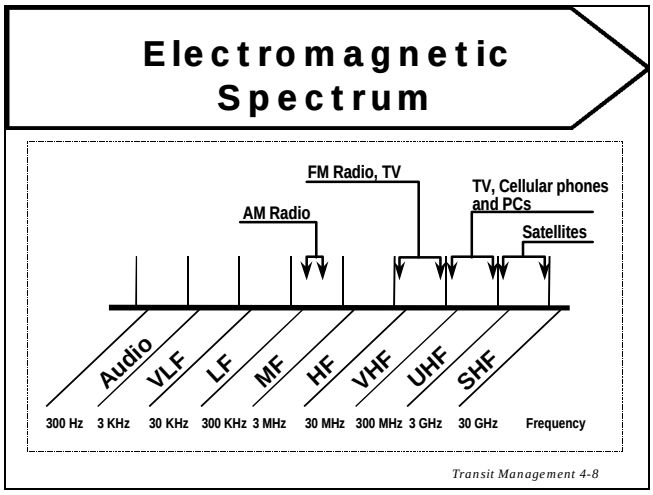
Telecommunications Issues, Continued

Slide: Electro-magnetic Spectrum



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Telecommunications Issues, Continued

Transit issues

Explain that there are numerous telecommunications applications in use by transit everyday

- As new technology requires increasing information exchange, telecommunications needs will also increase.
- With emerging APTS technology, an already crowded electromagnetic spectrum will only add to the competition for the limited resources.

Say: With the advent of new technologies and an increased use of radio bands for cellular phones, two-way radios, vehicle location, etc., the radio frequency spectrum is filling rapidly. In an attempt to meet these demands for mobile radio bands and to optimize the use of the spectrum, the FCC is refarming the spectrum – and we will talk more about that in a few minutes.

This chart illustrates the portion of spectrum most widely used starting on the low end with audio frequency and extending to the Super High Frequency on the high end. It also shows:

- The placement of things familiar to us such as AM and FM radio. The spectrum has been allocated or licensed for these applications.
- Frequencies associated with ITS Transit applications are:
  - ◊ 450 MHz – 512 MHz
  - ◊ 800 MHz bands

Show *where these frequencies fall on the slide and refer to the "U.S. Frequency Allocation" wall chart.*

- **Tell** the students they can get a closer look at the wall chart during the exercise.

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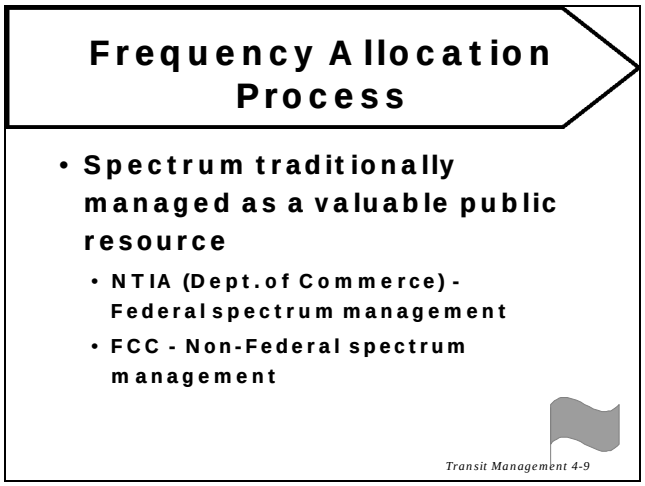
Telecommunications Issues, Continued

Slide: Frequency Allocation Process



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Telecommunications Issues, Continued

Frequency allocation process

Explain that this is a "red flag" issue:

Spectrum has traditionally been managed as a valuable public resource with allocation decisions made by Federal agencies.

- The National Telecommunications and Information Administration (NTIA) is responsible for managing radio frequency spectrum dedicated for Federal government use (largely for Dept. of Defense applications).

- The Federal Communications Commission (FCC) is responsible for managing all non-Federal radio frequency spectrum, including public transportation radio uses.
  - ◊ The process for acquiring or reallocating use of spectrum is a public process, accompanied by solicitation of public comments on notices of proposed rulemakings and rulemakings. This process is managed by the FCC.

Reference: How FCC Rules Are Made - series of Fact Sheets and Information Bulletins available from the FCC.

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Telecommunications Issues, Continued

Licensing

Say:

Systems operated by the private sector and by state and local government agencies that radiate energy must be licensed by the Federal Communications Commission in terms of their use of the electromagnetic spectrum.

- e.g., radar communications like the X band and K band traffic radar used by police departments

Some Advanced Public Transportation Systems functions can be handled by low-power electromagnetic devices that do not require licensing.

- e.g., signposts and signal preemption units

You may contact Joe LoVecchio at the Volpe Center (617-494-2131) if you want to talk about specific licensing issues.

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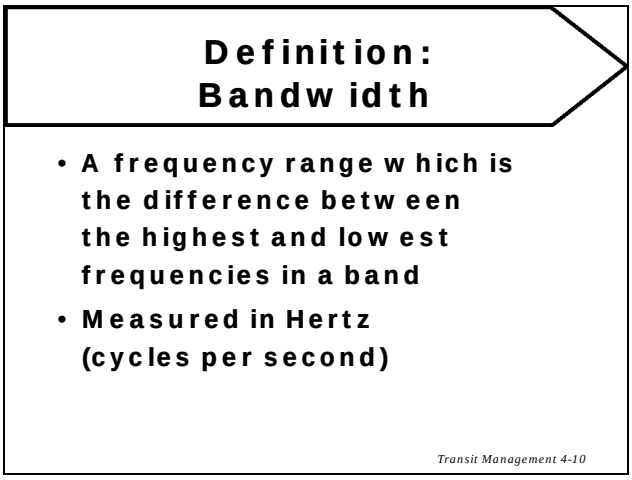
Telecommunications Issues, Continued

Slide: Definition: Bandwidth



Definition: Bandwidth

Explain that bandwidth can be thought of as capacity.

- The larger the bandwidth, the more information can be transmitted. Transmissions occur over a frequency range.
  - ◊ e.g., the FCC makes a certain amount of bandwidth available for AM radio station transmissions in an area, even though we tune to a specific frequency point on our radios.
  - ◊ e.g., TV is the same – there is a certain amount of bandwidth that carries television signals, but we "tune" to a specific channel.

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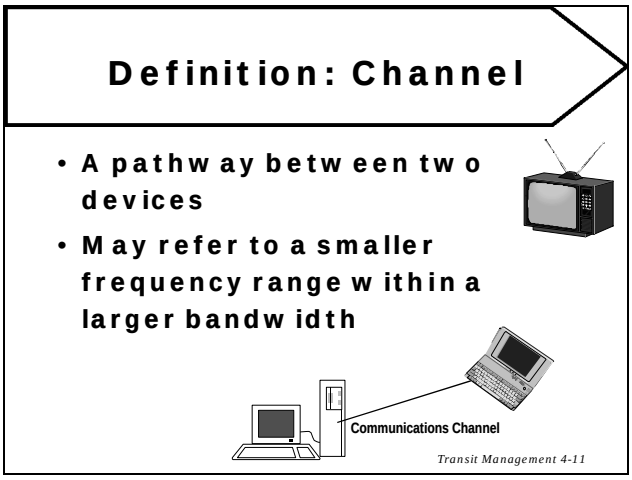
Telecommunications Issues, Continued

Slide: Definition: Channel



Definition: channel

Explain channel:

Say: We're used to tuning to TV or radio channels. These are sub-allocations of bandwidth within the frequency range allocated for these purposes by the FCC.

- Similarly, wireline transmissions can also be divided into channels, such as is commonly done for computer networks.

Review

Ask: Are there any questions on any of the terms we've covered so far? Why are these terms (bandwidth, channel, telecommunications, electromagnetic spectrum, etc.) important to bring into our discussion of telecommunications for transit technologies?

Answer: Overcrowding of the spectrum is leading to the creation of more channels with smaller bandwidth. This may require transit agencies to acquire new equipment to accommodate the new channel bandwidth.

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Telecommunications Issues, Continued

Slide: Where We Are Now

Where we are now

Currently, conventional mobile radio services are the most widely used transit telecommunications technology.

A transit agency can:
- be licensed for a particular use (dedicated spectrum)
- own their own radio tower and equipment (transit owned systems)

Future

Some transit agencies have converted their systems to digital to squeeze more out of the available spectrum.

As new technologies are being implemented, agencies are planning for updating their conventional telecommunications systems to keep up with their needs.

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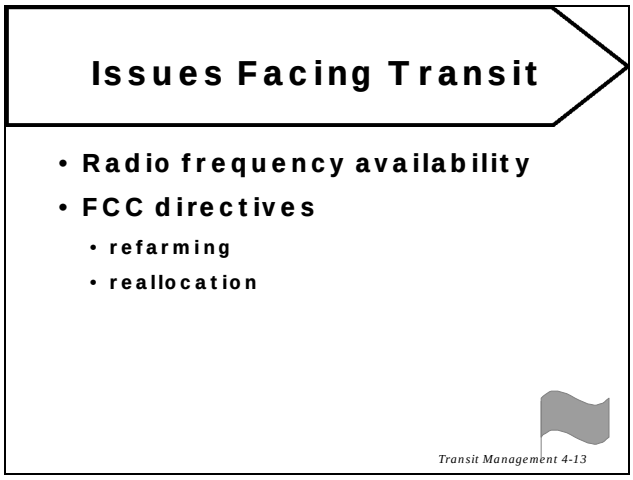
Telecommunications Issues, Continued

Slide: Issues Facing Transit



Telecom-issues facing transit

Explain: Advanced Public Transportation Systems technologies will create a need for new communications requirements.

Some of the issues facing transit are:

- current strain on the crowded electromagnetic spectrum
- frequency allocation availability
- Federal Communications Commission directives:
  - ◊ refarming of mobile radio bands
  - ◊ role of transit in public safety
  - ◊ growing concern over lack of spectrum dedicated for public safety use

Continued on next page

Telecommunications Issues, Continued

Refarming

Say: One major "red flag" issue facing transit is the refarming of radio communication bands.

- Under refarming, the mobile radio communication bands will be partitioned into narrower channels.
  - ◊ The conventional mobile radio frequency allocation is segmented into 25KHz channels.
  - ◊ Under spectrum refarming, the 25KHz mobile radio channels will be partitioned into smaller channels.
  - ◊ This reduction will be phased in by steps, initially from 25 to 12.5 kHz, and in the future from 12.5 to 6.25 kHz.
  - ◊ The rules proposed by the FCC would create up to 4 times the number of channels currently available.

- This reduction in the size of each channel will make current transit communication equipment obsolete in the future.
  - ◊ Any property planning, purchasing replacements, or new communications systems need to specify compatibility of that system with the reduced channel bandwidth requirement.

- This issue is the subject of a recent Transit Cooperative Research Program report, *Impact of Radio Frequency Refarming on Transit Communications.*

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Telecommunications Issues, Continued

Spectrum reallocation

Say: Another "red flag" issue is reallocation of spectrum.

Portions of the spectrum formerly controlled by federal government agencies are being turned over to the Federal Communications Commission.

Explain that the FCC is:

- an independent government agency that encourages competition in the telecommunications markets
- reallocating spectrum for private sector use
- auctioning off new spectrum opportunities
  - ◊ Current policy offers some protection to the public transit spectrum from the auctioning process because it is part of the public safety service.
  - ◊ Costs may increase due to the more competitive market.
- refarming spectrum already controlled by FCC
  - ◊ transition costs to transit as change is made to narrowband systems

Staffing consi-derations

Say: A word of warning here: intelligent transportation technology is high on the complexity scale. If you don't have a telecommunications expert on your staff, you will need help from an outside expert or consultant.

Continued on next page

Telecommunications Issues, Continued

Issues

Say: One issue facing transit as the integration of systems becomes more necessary is the compatibility with existing exterior systems, such as:

- planning and operations databases do not match up
  - ◊ FCC and Public Safety
  - ◊ National Architecture

The industry is beginning to demand this compatibility with exterior systems, and it is one thing to keep in mind when thinking about upgrading any of your systems.

- We'll discuss the issue again in the next module on Transit Operations Software.

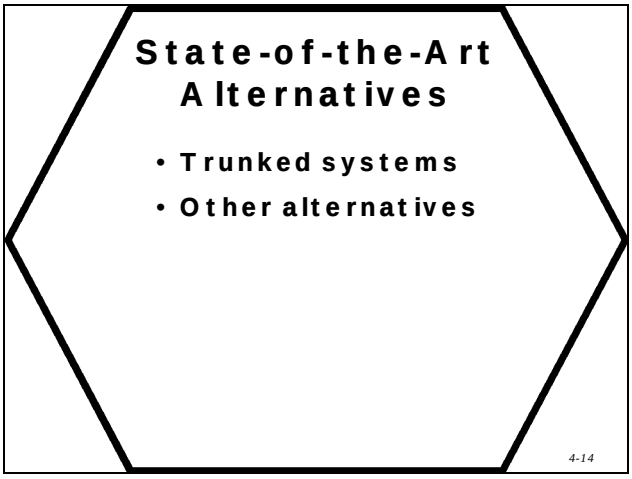
State-of-the-art innovative strategies

The decision to use state-of-the-art communications services to deal with these issues should take into account the cost of operation, the availability of spectrum, and the ability to meet performance requirements.

State-of-the-Art Alternatives

Length 30 minutes lecture/discussion.

Slide: State-of-the-Art Alternatives



Issues

Explain outline of lecture/discussion.

Say:

- We'll talk a little about trunked systems, since the transit industry focus is on this technology at this point.

There is material in your student guides which we have provided to you for your reference regarding other alternatives currently available.

- If you are interested in this topic, we'll have a list of where to get additional information at the end of the module.

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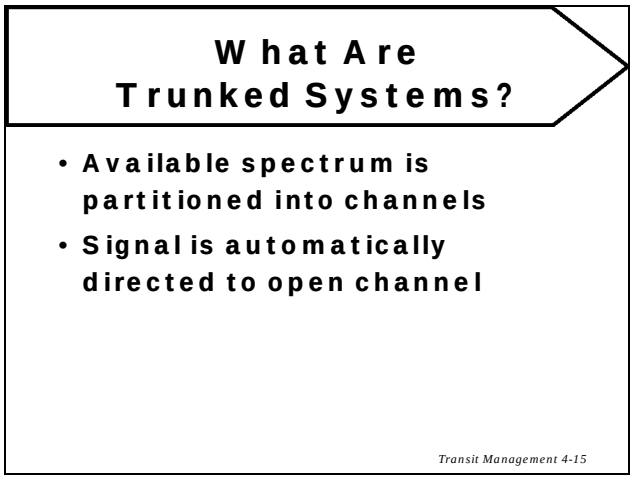
State-of-the-Art Alternatives, Continued

Slide: What Are Trunked Systems?



Trunked radio

Explain that trunked radio is the most popular of the new technologies and is often implemented in conjunction with other APTS functions, such as Automatic Vehicle Location (AVL). In the trunked radio system:

- available spectrum is partitioned into channels
- received or transmitted signals are automatically directed to whatever channel is currently open
- spectrum use is more efficient

Trunked radio networks

Say: Trunked radio networks permit multiple users to share a common group of channels in order to:

- increase the loading per channel
- decrease the probability of a call being blocked because a channel was unavailable

Explain that these systems are licensed under the FCC category *specialized mobile radio systems.*

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State-of-the-Art Alternatives, Continued

Advantages discussion

Ask the following questions and write the answers on the board:

- Are there any benefits to the passenger in a trunked system?
- How could trunked systems benefit the agency?
- What would it do to your operating costs if you had to implement a trunked system?
- What would it do to your staffing and training needs?
- Can you think of any risks?

Review the answers.

- **Say**: Let's compare your answers with our slides.

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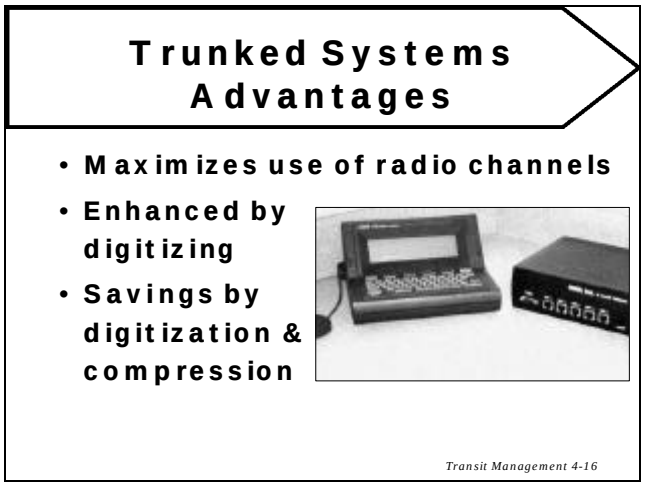
State-of-the-Art Alternatives, Continued

Slide: Trunked Systems Advantages



Trunked systems advantages

Review any item on the slide not already covered.

As with most of the telecommunications technologies, the benefits primarily affect the agency rather than the passenger.

- Trunked systems maximize the use of radio channels.
- Existing analog systems are enhanced and compressed by digitizing, which frees up more spectrum.
- With trunked systems, cost savings are realized by digitization and compression of the signal.

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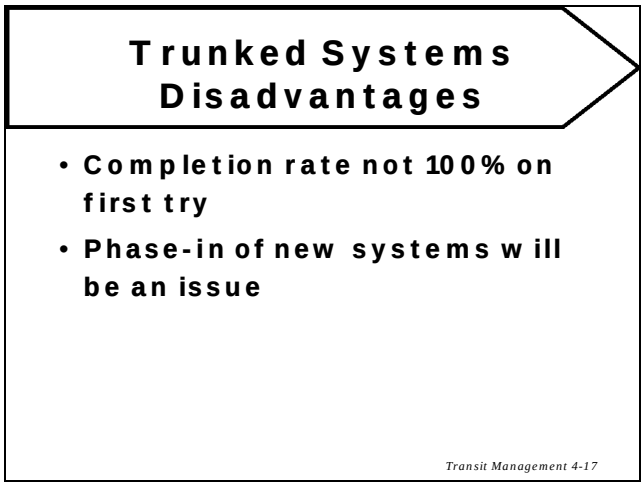
State-of-the-Art Alternatives, Continued

Slide: Trunked Systems Dis-advantages



Trunked systems Dis-advantages

Review any item on the slide not already covered.

- Historically, the completion rate has not been 100% on the first try.
  - ◊ Although trunked systems partition available spectrum into channels, (a smaller "window of opportunity" for successful transmission and reception) the received or transmitted signals are automatically directed to whatever channel is currently open (instead of by a manual search), making it more efficient than conventional systems.
- The crowded spectrum is a problem when phasing in ITS technologies while current operations must continue uninterrupted.

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State-of-the-Art Alternatives, Continued

Estimated capital costs

A DOT nationwide APTS inventory conducted by the Volpe National Transportation Systems Center indicated a range for the capital cost of trunked radio communications systems of $1,100 to $7,700 per vehicle. However, this was only based on 3 responding agencies.

For more information, see the report *Operation Timesaver – ITI Transit Components* on the Internet page: *http://www.fta.dot.gov/library/technology/APTS/iti/iti.htm*

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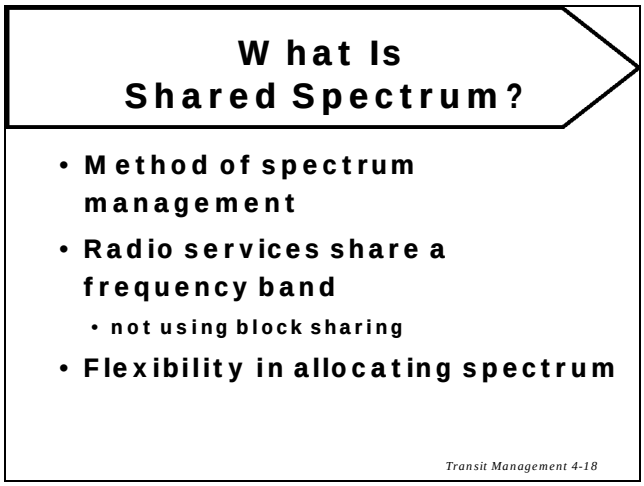
State-of-the-Art Alternatives, Continued

Slide: What Is Shared Spectrum?



What is shared spectrum?

Say:

- Shared spectrum is a method of spectrum management where users coexist on a shared spectrum basis with other non-transit public users through the use of the digital features of trunking.
- This is an alternative to using dedicated spectrum for vehicle communications: to seek status as a secondary user, where permission to operate on a non-interfering basis to primary users may be possible.

If you are considering using shared spectrum, keep in mind the following issues:

- geographical (distance between users)
- time sharing
- class of service (e.g., sharing between fixed and mobile services)
- type of user (e.g., emergency services/public works)

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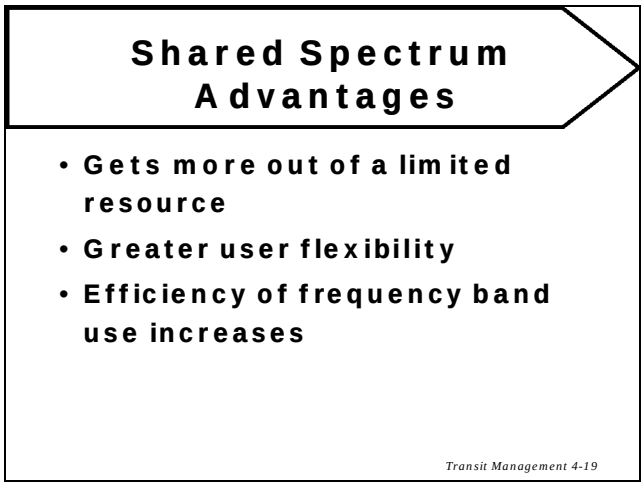
State-of-the-Art Alternatives, Continued

Slide: Shared Spectrum Advantages



Shared spectrum advantages

Review the slide.

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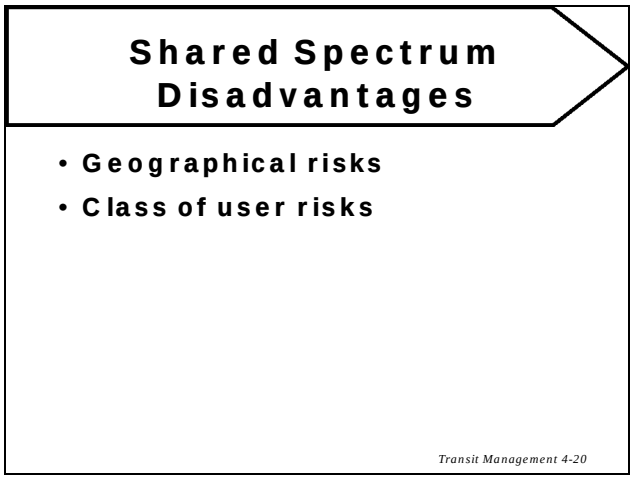
State-of-the-Art Alternatives, Continued

Slide: Shared Spectrum Dis-advantages



Shared spectrum dis-advantages

Review the slide.

- If the geographical distance between users who share is not appropriate, interference and inconvenience may be a problem. Also, the cost savings may not be significant.
- The user you share with might not be a good match.
  - ◊ time sharing
  - ◊ class of service (e.g., sharing between fixed and mobile services)
  - ◊ type of user (e.g., emergency services/public works)

Continued on next page

State-of-the-Art Alternatives, Continued

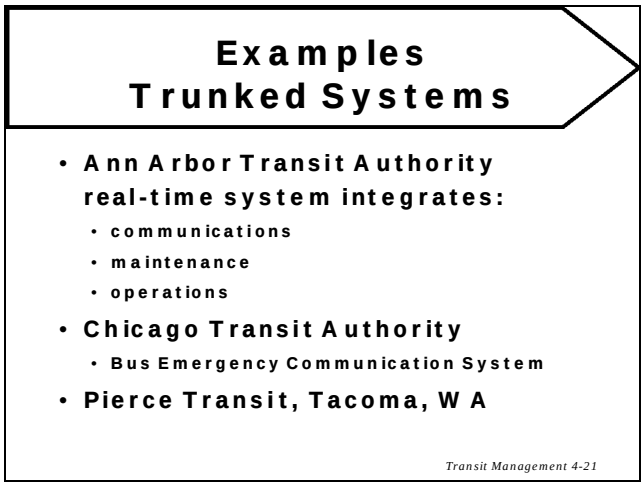
Review

Ask: Who can give me a quick description to review what a trunked radio telecommunications system is?

Answer:

- In a trunked radio system, available spectrum is partitioned into channels so that the spectrum is used more efficiently. Signals that are received or transmitted are automatically directed to whatever channel is currently open.

Slide: Examples Trunked Systems



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State-of-the-Art Alternatives, Continued

Ann Arbor Transit Authority

Explain that the Ann Arbor Transit Authority (AATA) operates 5 paratransit vehicles and 27 bus routes 24 hours a day serving more than 4 million passengers a year. The AATA has integrated communications, maintenance, and operations into one real-time system. A trunked radio system and onboard computer control and monitor all vehicle subsystems. The system includes:

- computers and 800 MHz radios in every vehicle
- AVL using GPS and differential corrections broadcasts to the vehicles
- visual and audible announcements of next stop and route information
- emergency system that allows dispatchers to see a vehicle on a map when the driver reports a life threatening situation
- computer assisted transfer management that determines if passengers have time to make desired transfers and notifies drivers of connecting buses to wait for the transferring passenger
- automated passenger counting
- automatic, real-time monitoring of engine oil pressure, temperature, and other vehicle systems

Continued on next page

State-of-the-Art Alternatives, Continued

Chicago Transit

Say: Here's one that isn't a success yet, but is in the early development stages:

- The Bus Emergency Communication System (BECS) at Chicago Transit uses a two-way voice and data radio system to support more effective delivery of bus service. In early 1998, 264 buses are scheduled to be equipped.
- There are no similar systems like this in existence yet.

Note to instructor: San Antonio BMS system is like Chicago CTA.

Pierce Transit

Pierce Transit, Tacoma, WA:

- trunked 900 MHz system
- mobile data terminals

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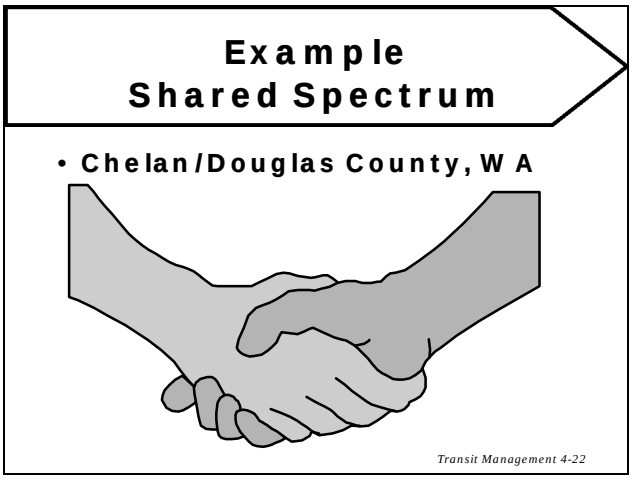
State-of-the-Art Alternatives, Continued

Slide: Example Shared Spectrum



Example: Chelan/ Douglas County

Chelan/Douglas County, WA

- joined with a local public utility system to share costs for a new 800 MHz trunked system

"In the state of Washington, there is an excellent example of what can be done by a transit agency to develop a modern communications system, given the spectrum limitations in existence. In need of a new communications system, Chelan/Douglas County Public Transit Agency made an extensive search to determine if they could partner with another public agency in the area that was planning to develop a new communications system. With the assistance of the Washington State Department of Transportation (DOT), that search was successful and the transit agency is partnering with a local public utility to develop and share a state-of-the-art trunked 800 MHz mobile radio communications system."

Source: Advanced Public Transportation Systems: The State-of-the-Art Update '98, page 2-5.

Continued on next page

State-of-the-Art Alternatives, Continued

Slide: Trunked Systems Review

OPTIONAL choices

Ask: Are there any questions on Trunked Systems?

Note to instructor: The following section, pages 40 – 52, is optional. Only use it if the class wants more discussion on these alternatives. If you elect to omit this section, be sure to point out the technology alternatives on the Telecommunications Technology Reference table at the end of the module.

To go directly to the last slide, Summary:

- The slideshow will skip to the summary slide on the next click, unless you choose not to.
- **Tell** the students that there is a lot of info in their SG on alternatives, which they can use for reference later.

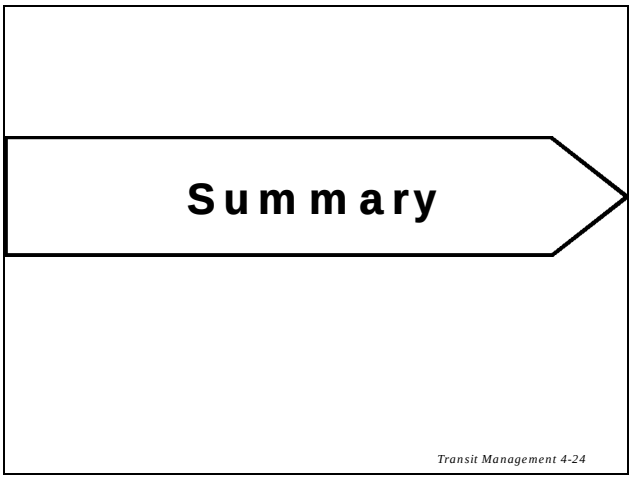
To choose alternatives for discussion:

- click on the photo in the slide.

Continued on next page

State-of-the-Art Alternatives, Continued

Slide: Summary



Summary

Explain resources that will provide students with additional information. Refer to the appendix for listings of related courses.

Transit Management Training Course	Title	ITS Professional Capacity Building		NTI course
		Technical Seminars	Short Courses	
Module 4: Transit Telecommunications	ITS Telecommunications Overview	X		
	Shared Resources for Telecommunications	X		
	ITS Telecommunications Analysis	X		

Review

Say: Turn to page 43 in your SG to Table 4-1: APTS Telecommunications Technology Reference.

- Take two minutes to review that now.
- If you'd like more information on any of those technologies listed, I can show you the background materials in your SGs.

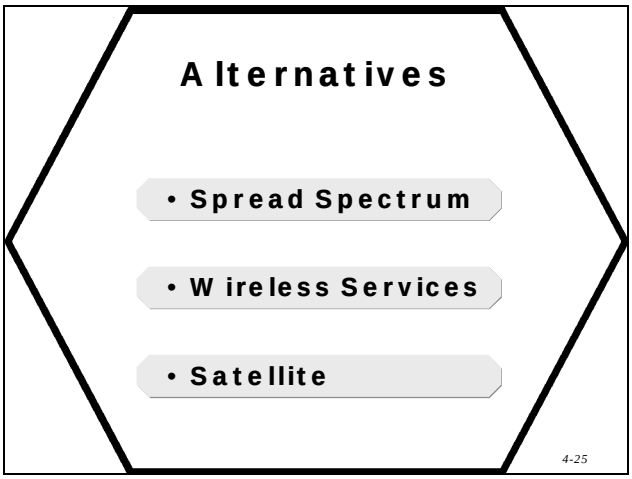
OPTIONAL: Technology Alternatives

OPTIONAL choices

Note to instructor: This section, pages 40 – 52, is optional. Only use it if the class wants more discussion on these alternatives.

To choose alternatives for discussion:

- click on the alternative the class wishes to discuss.



Turn to the matching section in the LG.

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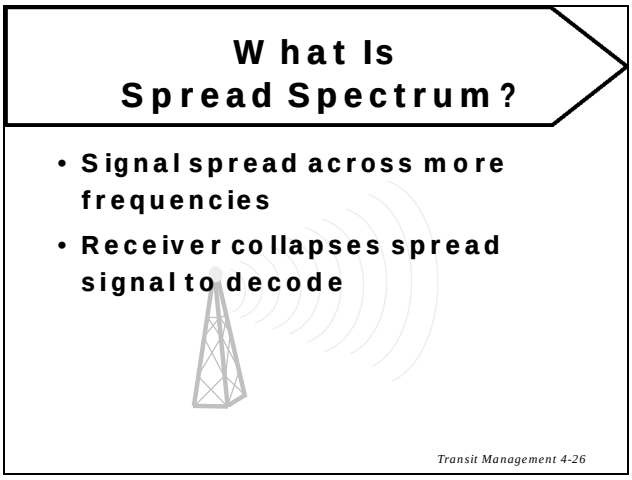
OPTIONAL: Technology Alternatives, Continued

Slide: What Is Spread Spectrum?



Spread spectrum features

Explain spread spectrum.

"Spread spectrum is a digital coding technique in which the signal is transformed or 'spread' over a frequency and it appears more like noise.

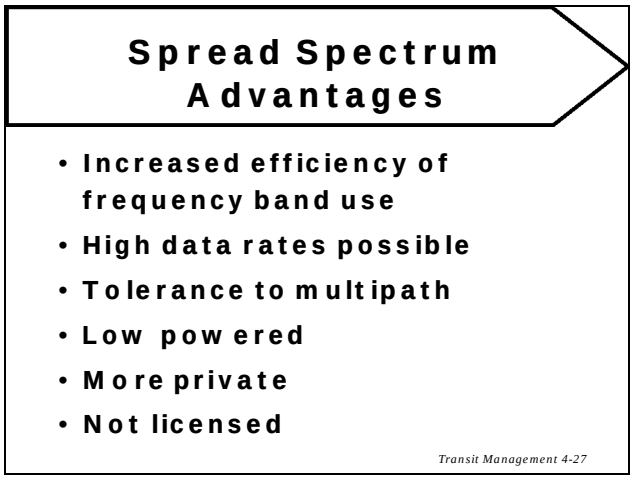
- With the signal's power spread over a larger band of frequencies, the result can be a signal that is less susceptible to impairment from electrical noise and other sources of interference.
- Knowing the spreading code used, the receiver can correlate and collapse the spread signal back down to its original form, making the information it carries intelligible only to the addressee."

Source: Muller, Nathan J. *Wireless Data Networking*, *http://www.ddx.com.glossary.html#G18*.

Continued on next page

OPTIONAL: Technology Alternatives, Continued

Slide: Spread Spectrum Advantages



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OPTIONAL: Technology Alternatives, Continued

Spread spectrum advantages

Say that new FCC regulations allowing unlicensed spread spectrum operation at low power levels have made its use convenient and effective for some applications.

Ask: Why use spread spectrum?
Answer: Spread spectrum:

- has a low probability of being intercepted or detected
- may be the only alternative in areas where heavy use of licensed channels makes it impossible to obtain a new license
- minimizes interference by unwanted signals
- has a high degree of precision in ranging
- has a high data rate-allowed bandwidth for spread spectrum, which makes high data rates attainable
- is tolerant to multipath, which are reflected waves that take longer to arrive at the receiver than the direct, desired waves
- may be a good choice for short range applications, such as traffic signal controls
- will allow an improvement in spectrum utilization efficiency of 3 to 15 times for digital cellular systems
- is low-powered
- makes it easier to keep the contents of the transmission private
- does not need to be licensed
- is affordable and reliable

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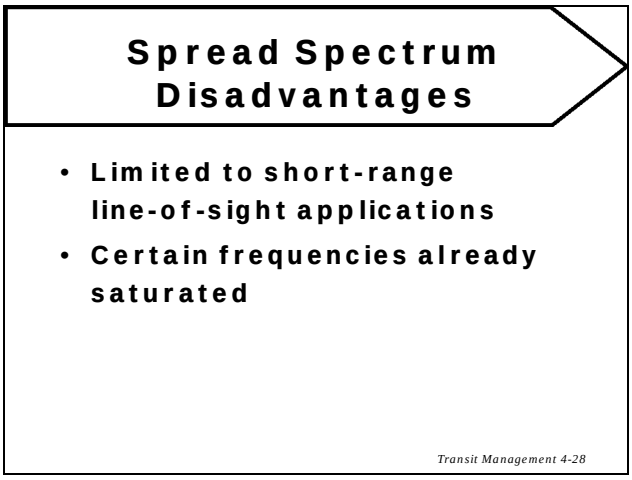
OPTIONAL: Technology Alternatives, Continued

Slide: Spread Spectrum Dis-advantages



Spread spectrum dis-advantages

Review any item on the slide not already covered.

Explain the disadvantages:

- Applications are limited to short range line-of-sight.
  - ◊ on the order of one mile
- Many other systems that radiate energy are present in unlicensed bands, which may lead to interference.
  - ◊ Some technologies are being developed to make interference less of a problem, e.g., frequency hopping.
- Number of users in certain frequency bands (900 MHz) is approaching saturation

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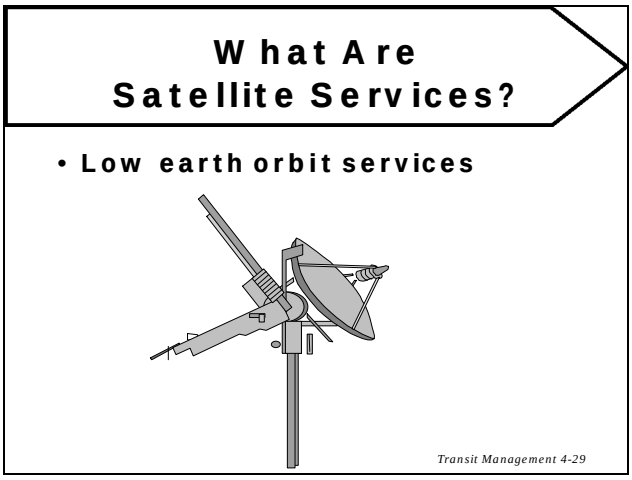
OPTIONAL: Technology Alternatives, Continued

Slide: What Are Satellite Services?



What are low earth orbit satellite systems?

Say:

Low earth orbit (LEO) satellite systems are comprised of a "constellation" of many small satellites at relatively low orbits.

- Their orbital heights are usually less than 2,000 km above the surface of the earth and have an orbit period of 90 minutes to 120 minutes.
- They use frequencies below 1 GHz and support data communications.
- They are smaller and cheaper to launch than traditional satellites.
- Orbiting earth and using solar energy, satellites receive and send information via microwave radiation.
- They receive information from one location, amplify it, and then send that information back to a different location.

Sources: See Appendix B: Web sites at the end of the student guide, under low earth satellites.

Continued on next page

OPTIONAL: Technology Alternatives, Continued

Satellite applications

Explain: Satellite communication systems are used for:

- mobile messaging and location for trucking, maritime, rail, barge, container, and other transportation industries
- fleet management and dispatch
- short, frequent, two-way status and location messages in a mobile environment

Other features include:

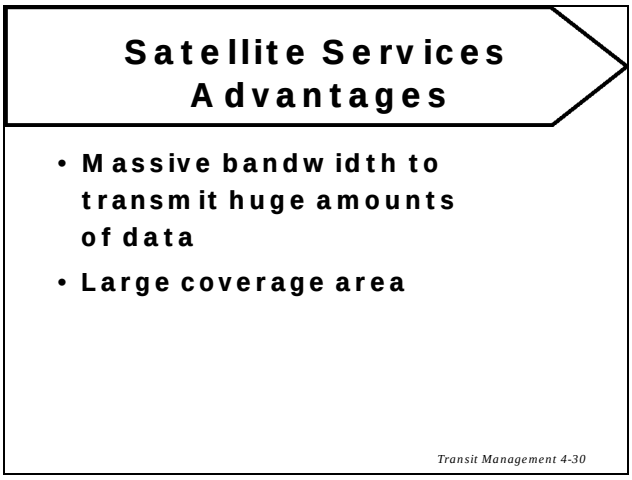
- The broadcast capabilities of satellites are versatile and easily customized. They allow for signals to be sent from one earth station to one or many other earth stations.
- Satellites have the capability to broadcast information gathered from many different sources to a single destination.
- While coverage zones are usually restricted due to land ownership, the actual capabilities of satellites are such that they can cover up to 42% of earth's surface.

Note to instructor: This field is changing rapidly. Try to find an update on satellite services before teaching the class.

Continued on next page

OPTIONAL: Technology Alternatives, Continued

Slide: Satellite Services Advantages



Satellite services advantages

Review any item on the slide not already covered.

Satellites are used for many reasons:

- Satellite communications take place within a massive bandwidth that is capable of transmitting large amounts of information.
- They are an affordable means of communicating information without distance related financial burdens when a large coverage area is required.

Continued on next page

OPTIONAL: Technology Alternatives, Continued

Slide: Satellite Services Dis-advantages

Satellite services dis-advantages

Review any item on the slide not already covered:

- Costs for service are expensive, but do not vary with range.
- Maintenance, repair, and updating costs of the satellites may cause an increase in service costs.
- Satellites may not reach your entire area.
  - ◊ e.g., urban canyons, tunnels, bridges

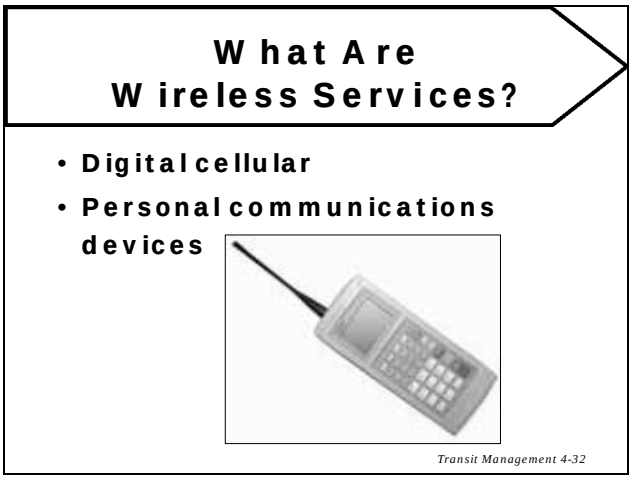
Note

Note to instructor: The use of satellite technology is very new for transit. No success stories exist yet for transit, although they have been used in the trucking industry.

Continued on next page

OPTIONAL: Technology Alternatives, Continued

Slide: What Are Wireless Services?



What are wireless services?

Say: In personal communications services (PCS), wireless communication is interfaced with a network access point by means of a standardized air interface protocol without the use of any hardwired connection to the network. These services allow some combination of terminal mobility and personal mobility.

Wireless and transit

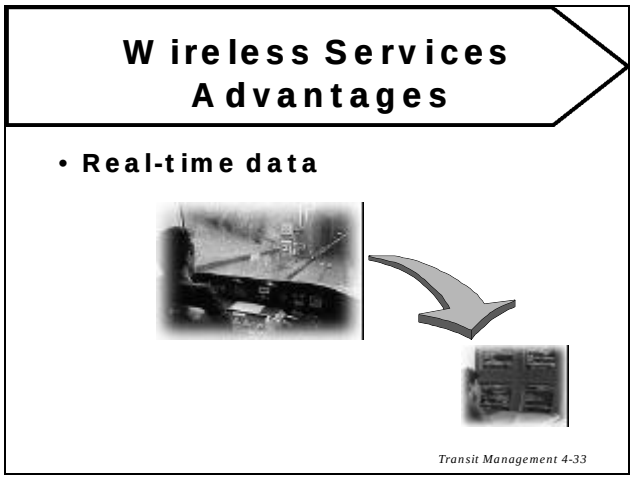
Explain

- Wireless data enables almost instant access to transit data.
- Such capabilities are already being used by many leading-edge transit authorities to dramatically extend the productivity, efficiency, and quality of service for their mobile professionals.

Continued on next page

OPTIONAL: Technology Alternatives, Continued

Slide: Wireless Services Advantages



Advantages

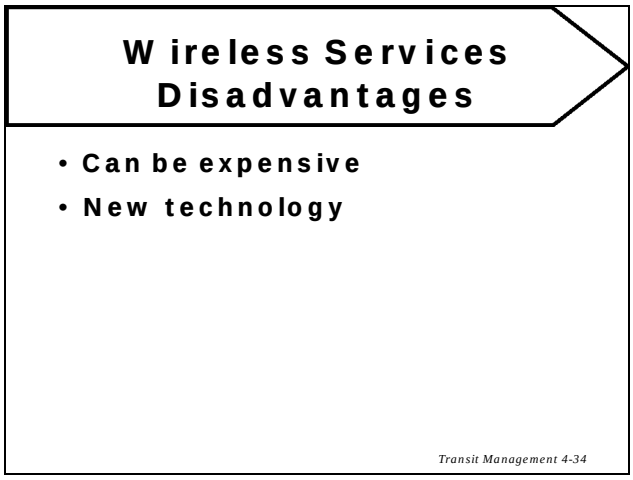
Review any item on the slide not already covered.

- Wireless services provide real-time data. Wireless communication is a state-of-the art technology that provides up to the minute data on all aspects of transit.

Continued on next page

OPTIONAL: Technology Alternatives, Continued

Slide: Wireless Services Dis-advantages



Wireless services dis-advantages

Review any item on the slide not already covered.

- Because this technology is relatively new, costs are high and transfer time via radio towers is at a premium.

Estimated capital costs

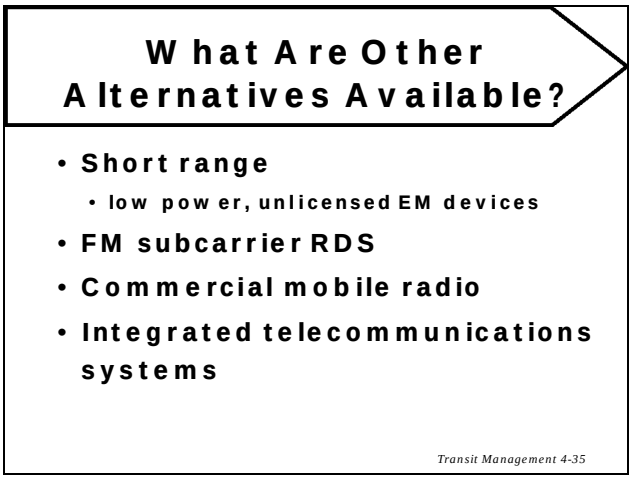
A DOT nationwide APTS inventory conducted by the Volpe National Transportation Systems Center estimates the capital cost of digital radio communications systems at an average of $2,400 per vehicle and a range of $300 to $4,500 per vehicle. However, this was only based on 2 responding agencies.

For more information, see the report *Operation Timesaver – ITI Transit Components* on the Internet page: *http://www.fta.dot.gov/library/technology/APTS/iti/iti.htm*

Continued on next page

OPTIONAL: Technology Alternatives, Continued

Slide: What Are Other Alternatives Available?



Other alternatives

Briefly **review** the other alternatives that are available to transit.

Explain a brief example of each of these technologies.

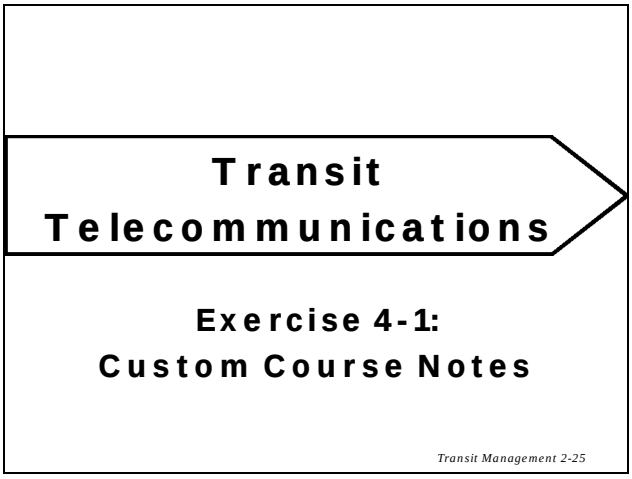
TABLE 4-1: APTS TELECOMMUNICATIONS TECHNOLOGY REFERENCE

Technology	***Description***	***Benefits, Costs, and Risks***
Spread Spectrum	Spread spectrum is a means of communicating by purposely spreading the spectrum (bandwidth) of a communication signal well beyond the bandwidth of the unspread signal.	• Low powered • High data rates possible • Efficient and affordable • More private • Short range line-of-sight applications • Tolerance to multipath • Certain bands already crowded
Shared Spectrum	Shared spectrum is a method of spectrum management where users coexist on a shared spectrum basis with other non-transit public users through use of digital features of trunking.	• Gets more out of a limited resource • Forces channel bandwidth efficiency • Greater user flexibility • Efficiency of frequency band increases
Trunked Radio	In the trunked radio system, the available spectrum is partitioned into channels so that the spectrum is used more efficiently. Signals that are received or transmitted, are automatically directed to whatever channel is currently open.	• Maximizes use of radio channels • Enhanced by digitizing • Savings by digitization and compression • Shortage of spectrum space
Low earth orbit satellite service	Low earth orbit (LEO) satellite systems are comprised of many small satellites at relatively low orbits. Low earth orbit satellite service receives information from one location, amplifies it, and then sends it back to a different location.	• New technology can be expensive • Doppler shift correction necessary • Satellites drift from intended path • Massive bandwidth to transmit huge amounts of data • Cost high and service still limited
Personal communications services	PCS is a set of capabilities that allows some combination of terminal mobility, personal mobility, and service profile management.	• Still in development • Limited coverage
Wireless services-cellular digital packet data	Wireless communication is interfaced with a network access point by means of a standardized air interface protocol without the use of any hardwired connection to the network. It is a state-of-the art technology that provides up to the minute data on all aspects of transit.	• New technology • Real-time data • Can be expensive

Exercise 4-1: Custom Course Notes

Length 30 minutes

Slide: Exercise 4-1



Leader instructions

Read the "In this exercise" and the directions to the class.

Say:

- Turn your student guides to the Atlanta Wireless Telecommunications case study on page _____. Read the case study, then answer the three questions on page _____.

- **Allow** ten minutes for the students to read the case study and answer the questions.

Note to instructor: *This exercise continues after the questions.*

In the exercise

You will:

- be able to describe the possible benefits of using Telecommunications in your transit systems

Continued on next page

Exercise 4-1: Custom Course Notes, Continued

Directions Read the example provided and answer the questions that follow.

Atlanta: Wireless telecomm-unications example

Wireless communication is interfaced with a network access point by means of a standardized air interface protocol without the use of any hardwired connection to the network. It is a state-of-the art technology that provides up to the minute data on all aspects of transit.

The Traveler Information Showcase:
During the summer 1996 Olympics, the surge of demand on Atlanta's transportation system presented a unique opportunity to demonstrate the benefits of ITS.

- The U.S. Department of Transportation (DOT) sponsored the development of a Traveler Information Showcase to demonstrate several ITS technologies available in this stressful transportation environment.

For four months (June through September, 1996), several hundred volunteers received personal communication devices or hand held computers equipped with wireless modems.

- Users enter their query for traffic and transit information.
- The device transmits the request to the fixed end server located in the Transportation Management Center in Atlanta.
- The fixed end server retrieves the information and transmits it via dedicated phone line to a wireless data network or paging facility where it is broadcast back to the user.

Source: Traveler Information Showcase home page.

Continued on next page

Exercise 4-1: Custom Course Notes, Continued

Question 1 How did wireless technology help Atlanta in the case? What problems may have come up because of this technology?

Question 2 What telecommunications issues do you face in your agency? In your region?

Continued on next page

Exercise 4-1: Custom Course Notes, Continued

Turn to Module 10

When students are finished with Exercise 4-1, direct them to Module 10.

Say: Open your book to Module 10, page _____. Using the student guide's information about telecommunications and your knowledge of your own region and agency, customize this quick reference to help you plan when you return to your office. Respond to each item as follows:

- In **item 1**, circle the types of communications that are currently used in your region. Highlight potential communications for future applications.

- In **item 2**, read each of the questions and answer yes or no. "Yes" answers suggest your interest in telecommunications technologies.

- Read **item 3** to identify which types of technology are best suited to solve particular problems.

- In **item 4**, tell the students to write their own action items and/or ideas that this module suggests to them. For example:
  - ◊ Are there any questions you want answered?
  - ◊ Were there any web sites that you wanted to look at when you return to the office?
  - ◊ Were there any courses or resources you wanted to find out more about?
  - ◊ Did we mention any transit example that you want more information about — who can you contact and where?

Continued on next page

Exercise 4-1: Custom Course Notes, Continued

For more information For additional information, use the following table to look up additional examples of what is going on in the field.

Telecommunications Examples			
Technology	**Story**	***Update '98***	**Additional info**
Trunked radio for AVL	CTA (Chicago Transit Authority) in Chicago		*Update '96* p. 16 and p. 27
Partnership	Chelan/Douglas	p. 2-5	Joined with local public utility system to share costs for a new 800 MHz trunked system